GEOLOGY, ENERGY, AND MINERAL (GEM) RESOURCE ASSESSMENT OF THE WASHAKIE GEM RESOURCE AREA (GRA), WYOMING, INCLUDING THE CEDAR MOUNTAIN WILDERNESS STUDY AREA (WY-010-222)

PHASE I

Contract No. YA-553-CT2-1055

Prepared for:

U.S. Bureau of Land Management

Prepared by:

Tetra Tech, Inc.
Pasadena, California

September 1983

QE
182
.W91
G46
c.3

#10793668 ID: 88076511

BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

QE
182
.W91
G46
c.3

EXECUTIVE SUMMARY

The U.S. Bureau of Land Management (BLM) has adopted a two-phase procedure for the integration of geologic, energy, and mineral (GEM) resources data concerning Wilderness Study Areas (WSAs). To facilitate this review, certain WSAs with similar geologic environments and mineral characteristics have been grouped together into larger GEM Resource Areas (GRAs). Using these guidelines, the Cedar Mountain WSA was grouped into the larger Washakie GRA. This report, which terminates the Phase I activities for the Washakie GRA, is an evaluation and interpretation of existing data concerning the GEM resource potential in the WSA.

The Washakie GRA contains one WSA, the Cedar Mountain WSA (WY-010-222). The Cedar Mountain WSA is located in the BLM's Washakie Resource Area, Worland District, Wyoming.

The Cedar Mountain WSA is considered highly favorable for the potential occurrence of oil and gas resources (classified 4D). This designation is based upon abundant direct and indirect evidence (Petroleum Information Corporation, 1982). The WSA has a moderate favorability for the potential occurrence of coal (classified 3C); this classification is based on direct but quantitatively minimal evidence (U.S. Geological Survey, 1964). Quantitatively minimal direct evidence exists to support a low favorability classification for the potential occurrence of all other GEM resources in the WSA (classified 2C). This classification is based on the geologic environment and inferred geologic processes that have been identified in the WSA.

Additional geologic investigations would help supplement the GEM resource evaluation of the Washakie GRA. An examination of well logs from the area would help identify and evaluate suitable stratigraphic and structural horizons for the accumulation of hydrocarbons. A moderate amount of geologic information exists which needs to be reviewed by BLM personnel to gain additional insight into the potential occurrence of GEM resources in the region prior to making wilderness decisions.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY.......... i

1.0 INTRODUCTION.......... 1

1.1 Purpose of Study.......... 1
1.2 Location and Access.......... 1
1.3 Basis for Report.......... 3

2.0 GEOLOGY.......... 5

2.1 General.......... 5
2.2 Physiography.......... 5
2.3 Geologic Units.......... 5
2.3.1 Bedrock Units.......... 5
2.3.2 Surficial Deposits.......... 8
2.4 Structural Geology.......... 8
2.5 Engineering Geology.......... 9
2.6 Paleontologic Resources.......... 9
2.7 Historical Geology.......... 9

3.0 ENERGY AND MINERAL RESOURCES.......... 10

3.1 General.......... 10
3.2 Potential Resources.......... 10
3.3 Land Status.......... 12
3.4 Deposit Types.......... 12
3.5 Resource Economics.......... 12
3.5.1 Oil and Gas.......... 12

TABLE OF CONTENTS
(continued)

4.0 LAND CLASSIFICATION FOR GEM RESOURCE POTENTIAL........................ 14

- 4.1 General.. 14
- 4.2 Oil and Gas.. 14
- 4.3 Coal... 17
- 4.4 Other GEM Resources.. 17

5.0 RECOMMENDATIONS FOR FURTHER WORK.................................. 17

- 5.1 Work Recommended to Complete Data Base....................... 17

6.0 REFERENCES AND SELECTED BIBLIOGRAPHY............................... 17

FIGURES

1.1 GRA Location Map.. 2
1.2 Topographic Map... 4
2.1 Geologic Map.. 6
2.2 Generalized Stratigraphic Column.................................. 7
3.1 Mineral Occurrence Map.. 11
3.2 Claim and Lease Map... 13
4.1 Land Classification Map... 15
4.2 Resource Classification Scheme.................................... 16

GEM RESOURCE AREA
WASHAKIE

1.0 INTRODUCTION

1.1 Purpose of Study

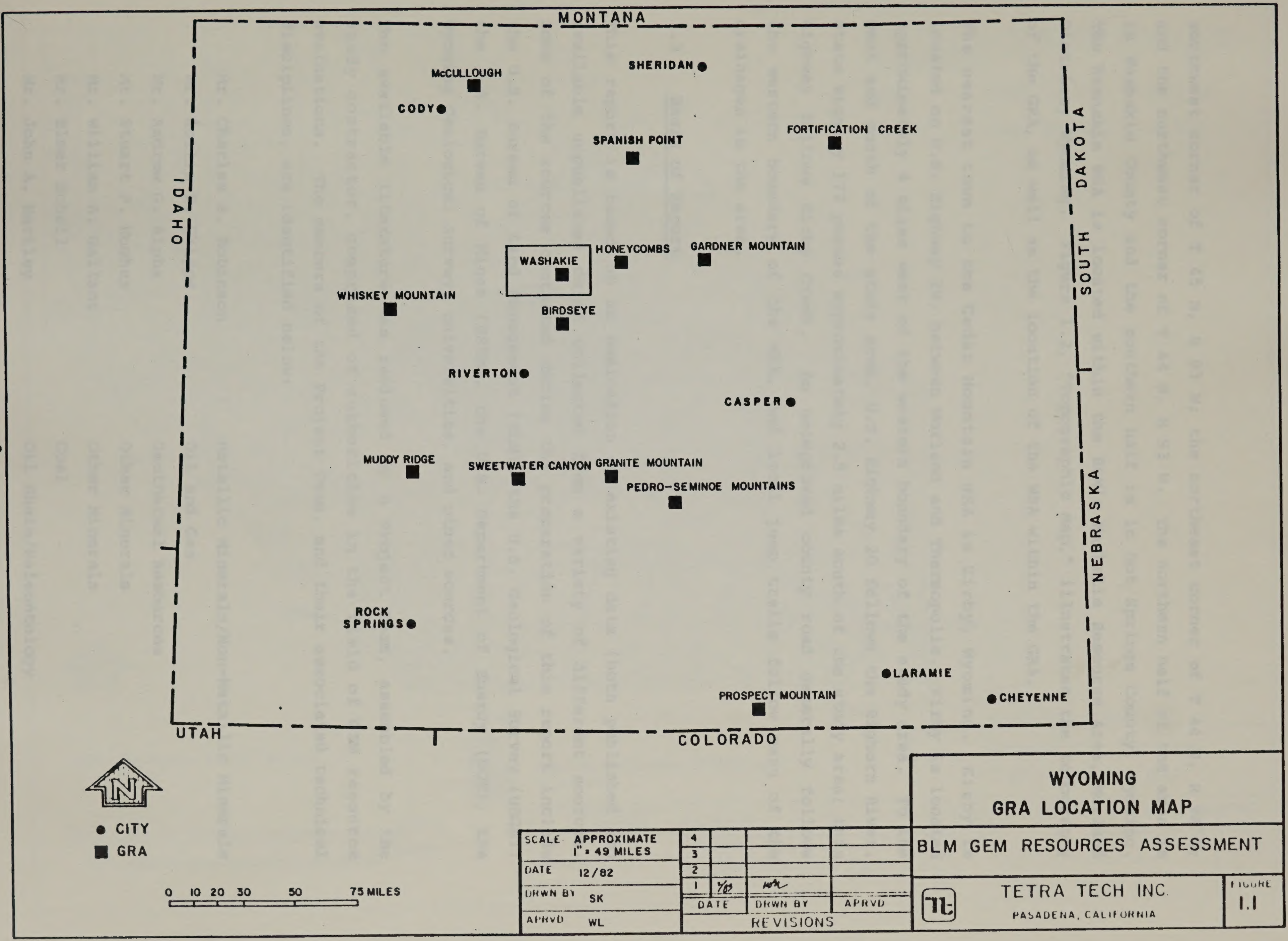
The U.S. Bureau of Land Management (BLM) has adopted a two-phase procedure for the integration of geologic, energy, and mineral (GEM) resources data for suitable/nonsuitable decisions concerning Wilderness Study Areas (WSAs). Phase I consists of a review and evaluation of existing data, resulting in an interpretation of the GEM resource potential of the WSAs. Phase II is designed to generate only the additional data required to support the GEM resource recommendations presented during Phase I. To facilitate this review, certain WSAs with similar geologic and mineral characteristics have been grouped together into larger GEM Resource Areas (GRAs). Using these guidelines, the Cedar Mountain WSA was grouped into the larger Washakie GRA. This report, which terminates the Phase I activities for the Washakie GRA, is an evaluation and interpretation of existing data concerning the GEM resource potential in the Cedar Mountain WSA.

The GEM resource evaluations for this study were performed by Tetra Tech, Inc. for the U.S. Bureau of Land Management, under Contract No. YA-553-CT2-1055. This study was completed in January, 1983.

1.2 Location and Access

This GEM report covers the area identified as the Washakie GEM Resource Area (GRA); the geographic location of the study area is shown in Figure 1.1, "GRA Location Map."

The Washakie GRA contains one WSA, the Cedar Mountain WSA (WY-010-222). The Cedar Mountain WSA contains approximately 21,570 acres, and is located between 43° 40'-57' latitude and 108° 02'-06' longitude. The WSA is located in the southeast corner of Township (T) 45 North (N), Range (R) 94 West (W); the



SCALE	APPROXIMATE 1" = 49 MILES	4			
		3			
DATE	12/82	2			
		1	1/83	WH	
DRWN BY	SK		DATE	DRWN BY	APRVD
APRVD	WL		REVISIONS		

WYOMING
GRA LOCATION MAP

BLM GEM RESOURCES ASSESSMENT

TETRA TECH INC.
PASADENA, CALIFORNIA

FIGURE
1.1

southwest corner of T 45 N, R 93 W; the northeast corner of T 44 N, R 94 W; and the northwest corner of T 44 N, R 93 W. The northern half of the area is in Washakie County and the southern half is in Hot Springs County, Wyoming. The Washakie WSA is located within the BLM's Washakie Resource Area, Worland District, Wyoming. Figure 1.2, "Topographic Map," illustrates the topography of the GRA, as well as the location of the WSA within the GRA.

The nearest town to the Cedar Mountain WSA is Kirby, Wyoming. Kirby is located on U.S. Highway 20, between Worland and Thermopolis. Kirby is located approximately 4 miles west of the western boundary of the study area. To the west and south of the study area, U.S. Highway 20 follows the Bighorn River. State Highway 172 passes approximately 2.5 miles south of the study area; this highway follows Kirby Creek. An unimproved county road generally follows the western boundary of the WSA, and local jeep trails follow many of the drainages in the area.

1.3 Basis of Report

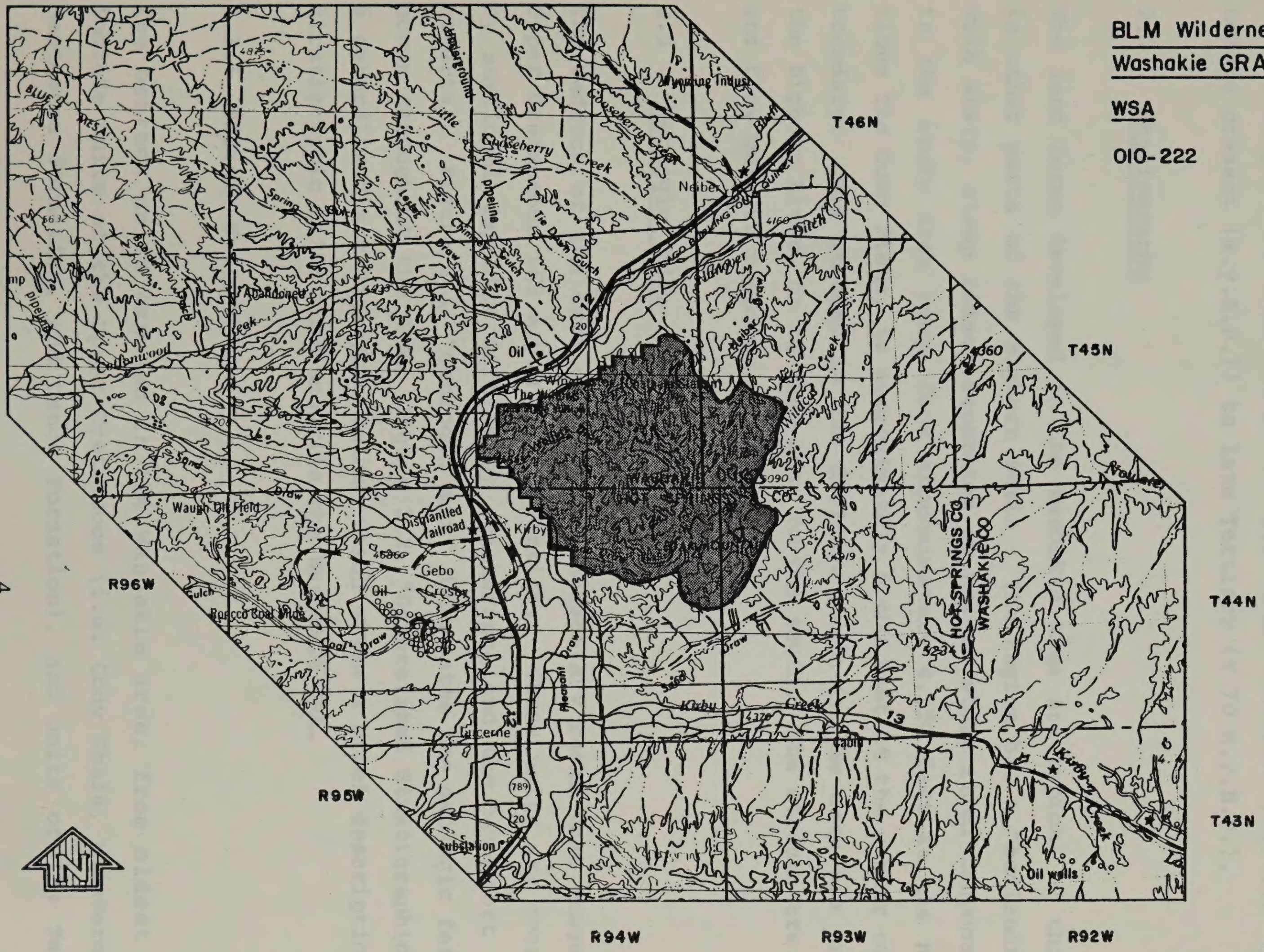
This report is based on an evaluation of existing data (both published and available unpublished data) collected from a variety of different sources. Some of the sources contacted during the preparation of this report include the U.S. Bureau of Land Management (BLM), the U.S. Geological Survey (USGS), the U.S. Bureau of Mines (USBM), the U.S. Department of Energy (DOE), the Wyoming Geological Survey, universities, and other sources.

The available literature was reviewed by a Project Team, assembled by the study contractor, comprised of authorities in the field of GEM resource evaluations. The members of the Project Team, and their associated technical disciplines, are identified below:

Mr. Charles S. Robinson	Metallic Minerals/Non-Metallic Minerals
Mr. Rollin E. Phipps	Oil and Gas
Mr. Andrew G. Alpha	Geothermal Resources
Mr. Stuart P. Hughes	Other Minerals
Mr. William A. Gallant	Other Minerals
Mr. Elmer Schell	Coal
Mr. John A. Hartley	Oil Shale/Paleontology

BLM Wilderness Study Areas Included in the Washakie GRA

WSA	NAME	ACREAGE
010-222	Cedar Mountain	21,570



(USGS, n.d.)
(USGS, 1955; revised 1974)

NOTE: Contours in 200ft. Intervals.

▨ Approximate Boundary of Wilderness Study Area

5 4 3 2 1 0 3 6 Miles
5 4 3 2 1 0 5 10 Kilometes

SCALE:	1" = 4 MILES 1:250,000
DATE:	12/82
DRWN BY	SK
APRVD:	WL

REVISIONS	DATE	DRWN BY	APRVD
4			
3			
2	8/83	HF	
1	3/83	SK	

Washakie GRA, Wyoming

TOPOGRAPHIC MAP

BLM GEM RESOURCES ASSESSMENT
REGION 6 WYOMING and MONTANA

TETRA TECH INC.
PASADENA, CALIFORNIA

FIGURE 1.2

2.0 GEOLOGY

2.1 General

The Washakie area is in the southern part of the Bighorn Basin, near the axis of the basin. The Bighorn Basin is filled with a thick sequence of sedimentary rocks that range in age from Cambrian (500-600 million years before present [m.y.B.P.]) to late Tertiary (< 70 m.y.B.P.).

2.2 Physiography

The land forms developed in the Washakie area are typical of those developed in other parts of the Bighorn Basin. The region has a "badlands" topography with sharp, steep ridges separated by narrow steep-sided canyons. Altitudes in the study area range from approximately 4,250 feet at the northern end, along Tie Down Flats, to approximately 5,400 feet at the center of the western boundary. The streams in the drainage basin in the area are tributaries to the Bighorn River, or to Sand Draw to the south. The streams are intermittent and flow only in response to storms.

2.3 Geologic Units

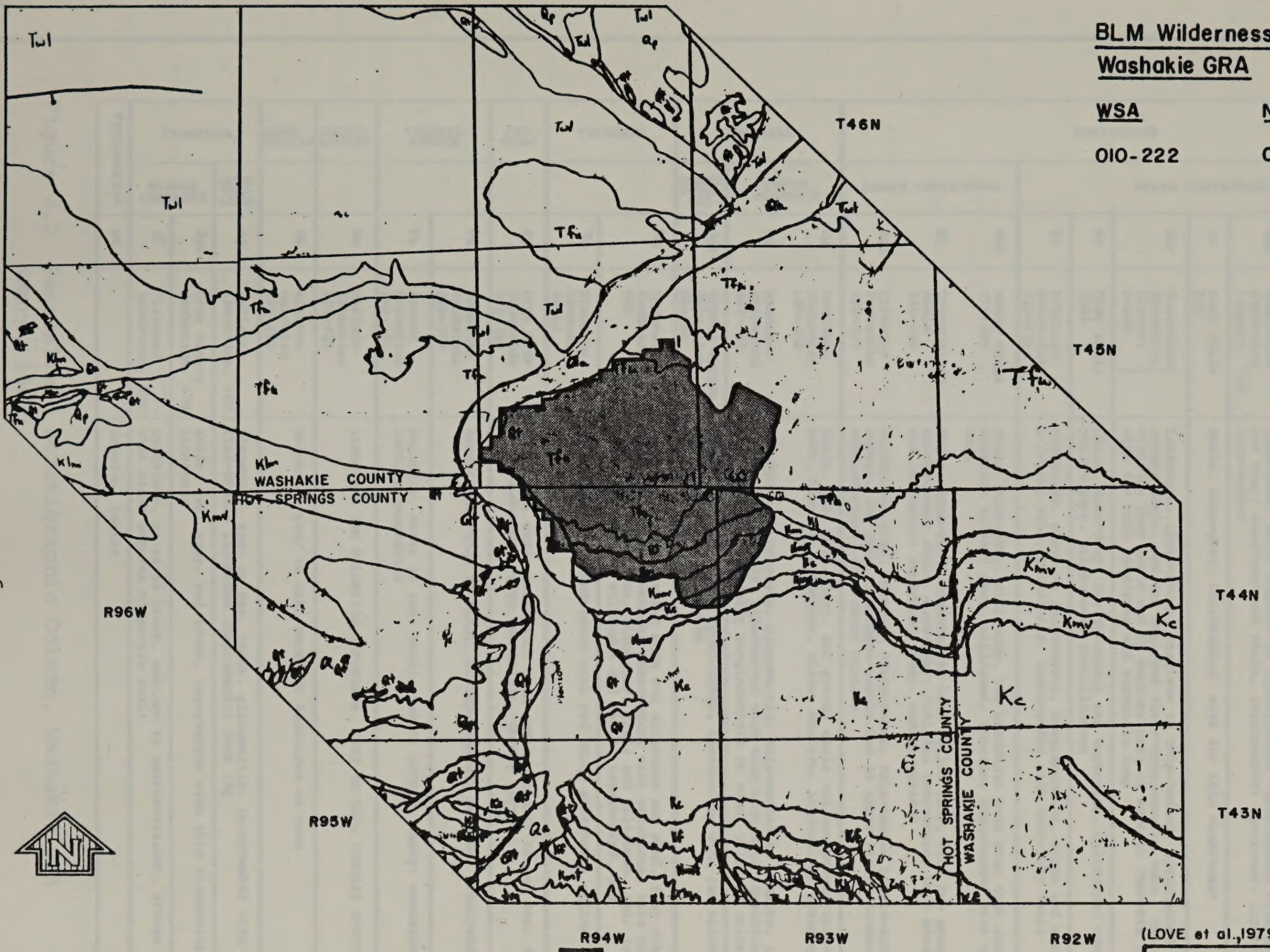
The bedrock of the area consists of sedimentary rocks that range in age from Upper Cretaceous (65 m.y.B.P.) to Tertiary. These units are overlain locally by surficial deposits derived by weathering, and the transport of weathered material. Figure 2.1, "Geologic Map," delineates the geologic formations that occur throughout the GRA. Figure 2.2, "Generalized Stratigraphic Column," is a generalized stratigraphic column which gives a brief description of all the stratigraphic units that underlie the Washakie GRA.

2.3.1 Bedrock Units

The bedrock units exposed in the Washakie area, from oldest to youngest include units of the Upper Cretaceous (i.e. Cody Shale, Mesaverde Formation, Meeteetse Formation, and Lance Formation), and units of the Tertiary (i.e.

BLM Wilderness Study Areas Included in the Washakie GRA

WSA	NAME	ACREAGE
010-222	Cedar Mountain	21,570



(LOVE et al.,1979)

▨ Approximate Boundary of Wilderness Study Area

5 4 3 2 1 0 3 6 Miles

5 4 3 2 1 0 5 10 Kilometer

SCALE 1" = 4 MILES 1: 250,000	4			
	3			
DATE 12/82	2			
DRWN BY SK	1	3/83	SK	
		DATE	DRWN BY	APRVD
APRVD WL	REVISIONS			

Washakie GRA, Wyoming

GEOLOGIC MAP

BLM GEM RESOURCES ASSESSMENT

REGION 6 WYOMING and MONTANA

TETRA TECH INC.

PASADENA, CALIFORNIA

FIGURE 2.1

SYSTEM	SERIES	SYMBOL	FORMATION, THICKNESS, FT	GENERAL LITHOLOGIC DESCRIPTION
QUATERNARY		Qa Qt Qp	Quaternary Undifferentiated	Silt, sand, gravel and boulders deposited by streams that eroded the area
TERTIARY	LOWER EOCENE	Twl	Willwood formation 500+	Shale and siltstone, gray-green to red, some carbonaceous shale, interbedded with few thin sandstones; sandstones, light-gray, crossbedded, contains thin beds of carbonaceous shale with plant fragments
	PALEOCENE	Tfu	Port Union formation 1000+	Shale, gray, containing numerous ironstone concretions, interbedded with thin sandstones; sandstone and shale; sandstone, gray to brown with shale and coal beds
CRETACEOUS	UPPER CRETACEOUS	Kl	Lance formation 700-1000	Sandstone, brown, interbedded with gray shale; dinosaur bone fragments; sandstone and gray shale, interbedded with carbonaceous shale; sandstone, light-gray, massive, crossbedded, contains numerous large oval calcareous sandstone concretions
		Kmt	Meeteetse formation, 410	Shale and sandstone, thin-bedded, interbedded with coal and bentonite; sandstone, gray, fine-grained, poorly consolidated, interbedded with shale and bentonite
		Kmv	Mesaverde formation (upper), 700	Sandstone, white medium- to fine-grained, interbedded with some carbonaceous shale and coal; sandstone and shale, interbedded; sandstone, light-brown, massive- to thin-bedded
		Kc	Cody shale 250	Shale, drak-gray, interbedded, with few thin sandstones
		Kmv	Mesaverde formation (lower) 0-300	Sandstone, light-brown, massive- to thin-bedded, interbedded with gray and carbonaceous shale, and few coal and chert-conglomerate beds. This unit intertongues with the Cody shale and in eastern part of area it consists of dark-gray shale with few thin sandstone and bentonite beds
		Kc	Cody shale 2800	Shale, dark-gray, few spherical and septatian, calcareous concretions; shale, yellow-gray, calcareous, fossiliferous
		Kf	Frontier formation 430-570	Sandstone, gray- to light-brown, conglomeratic, black and brown chert pebbles 1/2-inch size, lenticular, interbedded with dark-gray shale
	LOWER CRETACEOUS	Kmr	Mowry shale 270-290	Shale, dark-gray, siliceous, two bentonite beds near top; shale, dark-gray, weathers silvery gray, siliceous, fissile, interbedded with thin white clay beds
		Kt	Thermopolis shale 340-380	Shale, dark-gray, interbedded with yellow clay, with few zones of ironstone concretions; shale, dark-gray, dahllite concretions near base; shale, dark-gray, and bentonite; sandstone, gray, medium grained
		Kcl	Cloverly formation 190-230	Sandstone, gray, weathers rusty-brown, thin-bedded ripple-marked; shale red, maroon, and gray, limestone-cobble bed in upper part; sandstone, gray crossbedded, conglomeratic, with chert pebbles
JURASSIC	UPPER JURASSIC	Jm	Morrison formation 190-250	Shale, red, pink, gray, and green; shale and sandstone, thin-bedded; some sandstone beds, massive; sandstone, white, massive, lenticular, crossbedded
		Js	Sundance formation 200-330	Sandstone, gray-green, glauconitic, thin-bedded to massive, interbedded with green shale; shale, gray, interbedded with thin coquinoid limestones; sandstone, tan, medium-grained, locally conglomeratic at base, slightly calcareous
	MIDDLE JURASSIC	Jgs	Gypsum Spring formation 80-140	Shale, red and green, gypsiferous, interbedded with few siltstone and gray limestones; gypsum, white
TRIASSIC		T̄c	Chugwater formation 960	Shale, red, interbedded with red siltstone and pink, very fine-grained sandstone; sandstone, reddish-brown; interbedded with occasional thin beds of red shale and siltstone; limestone, blue-gray; shale and siltstone, red, interbedded with few thin gypsum beds; siltstone and shale, interbedded, red
		T̄d	Dinwoody formation 40-60	Gypsum, white, interbedded with red shale siltstone, yellow
PERMIAN		Pp	Park City formation 200-280	Limestone, gray, dolomitic, with nodular chert; shale, red, few thin limestone beds; limestone, gray, dolomitic, cherty layers
PENNSYLVANIAN		Pt	Tensleep sandstone 280-390	Sandstone, white to bluff, medium-grained, massive, crossbedded
		Pa	Amsden formation 190-290	Dolomite, white to tan; shale, red to purple, sandy; sandstone, gray to brown, locally quartzitic
MISSISSIPPIAN		Mm	Madison formation 325-425	Limestone and dolomitic limestone, gray to tan, locally cherty
ORDOVICIAN		Ob	Bighorn dolomite 150-200	Dolomite, gray to tan, massive; sandstone at base
CAMBRIAN	UPPER CAMBRIAN	Ꞓg	Gallatin limestone, 440	Limestone, gray to tan, sandy, glauconitic, interbedded with gray to green shale; flat-pebble limestone conglomerate near top
	MIDDLE CAMBRIAN	Ꞓgv	Gros Ventre formation, 470	Shale, red, gray, and green, interbedded with thin glauconitic sandstone and limestone
		Ꞓf	Flathead sandstone, 200	Sandstone, white to brown, medium- to coarse-grained, arkose at base, interbedded with minor amounts of purple shale
PRECAMBRIAN		pꞒ		Granite, gneiss

Figure 2.2 Generalized Stratigraphic Column, Washakie GRA (Horn, 1963).

Fort Union and Willwood Formation). The bedrock units, except for the Willwood Formation, crop out in a series of bands across the southern portion of the area from Sand Draw northward.

The Cody Shale, at the base, is a dark-gray marine shale. It grades upwards into the Mesaverde Formation, which consists of alternating beds of clay shale, siltstone, and massive sandstone and coal. The Meeteetse Formation also consists of beds of shale, or claystone, sandstone and coal, which grade upward into the Lance Formation. The Lance Formation consists of variegated claystone, siltstone, some sandstone and coal. The Fort Union Formation overlies the Lance Formation. The coal in the Fort Union Formation is restricted to the lower part of the Formation. More than half of the study area is underlain by the Fort Union Formation. The Willwood Formation is located at the northernmost point of the study area. The Willwood Formation consists primarily of sandstone and siltstone. It is characterized in the Bighorn Basin by the abundance of mammalian fossils.

Underlying the geologic formations that crop out in the Cedar Mountain WSA is a thick sequence of sedimentary rocks; in adjacent areas of the Bighorn Basin, these rocks have served as a source or reservoir rocks for oil and gas.

2.3.2 Surficial Deposits

The surficial deposits in the study area have been derived from the weathering of the bedrock; therefore, the surficial deposits reflect the characteristics of the bedrock. Colluvium, derived from in-place weathering, mantles most of the slopes. This material has been moved by running water from the toe of the slopes into the stream valleys to form alluvium. The alluvium consists primarily of silty sand.

2.4 Structural Geology

The Washakie area is on the southwestern flank of a gentle anticline. The axis of the anticline is approximately 2 miles northeast of the WSA. The sedimentary beds dip from about 5° to 25° to the south or southeast. Minor

fold structures in relation to facies changes could serve as traps for hydrocarbons in the area.

2.5 Engineering Geology

The shales in the area, and the soils derived from the shales, will be expansive, and should not be used in construction without proper engineering investigations. The geologic hazards that exist in the area are flash floods and expansive shales.

2.6 Paleontologic Resources

Marine invertebrate fossils are common locally in the Cody Shale and the Lower Mesaverde Formations. The fossils are typical of the late Cretaceous fossils found throughout Wyoming. Some vertebrate fossils and fossil wood have been reported from the Meeteetse and Fort Union Formations. The mammalian fossils in the Willwood Formation in the surrounding area have been recently studied in some detail (Bown, 1977; Lillegraven, 1982). A small portion of the Willwood Formation crops out in the northern part of the study area.

2.7 Historical Geology

The geologic history of the Washakie area is similar to the geologic history of the northern Rocky Mountains. The basement Precambrian (> 600 m.y.B.P.) rocks in the area consist of metaigneous and metasedimentary rocks, the origin of which is not well understood. At the end of Precambrian time, and throughout the Paleozoic (225 m.y.B.P.) era, there were repeated advances and retreats of the sea. Marine deposits of sandstone, siltstone, shale, and limestone were formed. At the end of the Paleozoic era, marine, marginal marine (evaporite), and terrestrial red-bed deposits were formed as the seas fluctuated back and forth over the area. Marine conditions returned in Jurassic (135-180 m.y.B.P.) time, only to retreat at the end of the Jurassic period. A major marine invasion started in the early Cretaceous period, and continued until the start of the Laramide orogeny near the end of the Cretaceous period. During the deposition of the Paleozoic and Mesozoic

(70-225 m.y.B.P.) sediments, stratigraphic traps for hydrocarbons developed along facies changes, unconformities, and lithologic boundaries. The Tertiary period was a period of land emergence from the sea; it was also a period of repeated uplift and continental erosion and deposition. The uplifts were accompanied by folding, thrusting, and high-angle faulting, together with the deposition of thick terrestrial sediments and coal in the intermountain basins. The tectonic activity formed structural traps for hydrocarbon accumulations. Volcanism was active in mid to late Tertiary time; thick volcanic deposits accumulated locally, and volcanic ash was widely distributed. The Quaternary (2-3 m.y.B.P.) period is noted for the extensive erosion of the bedrock in the area by streams.

3.0 ENERGY AND MINERAL RESOURCES

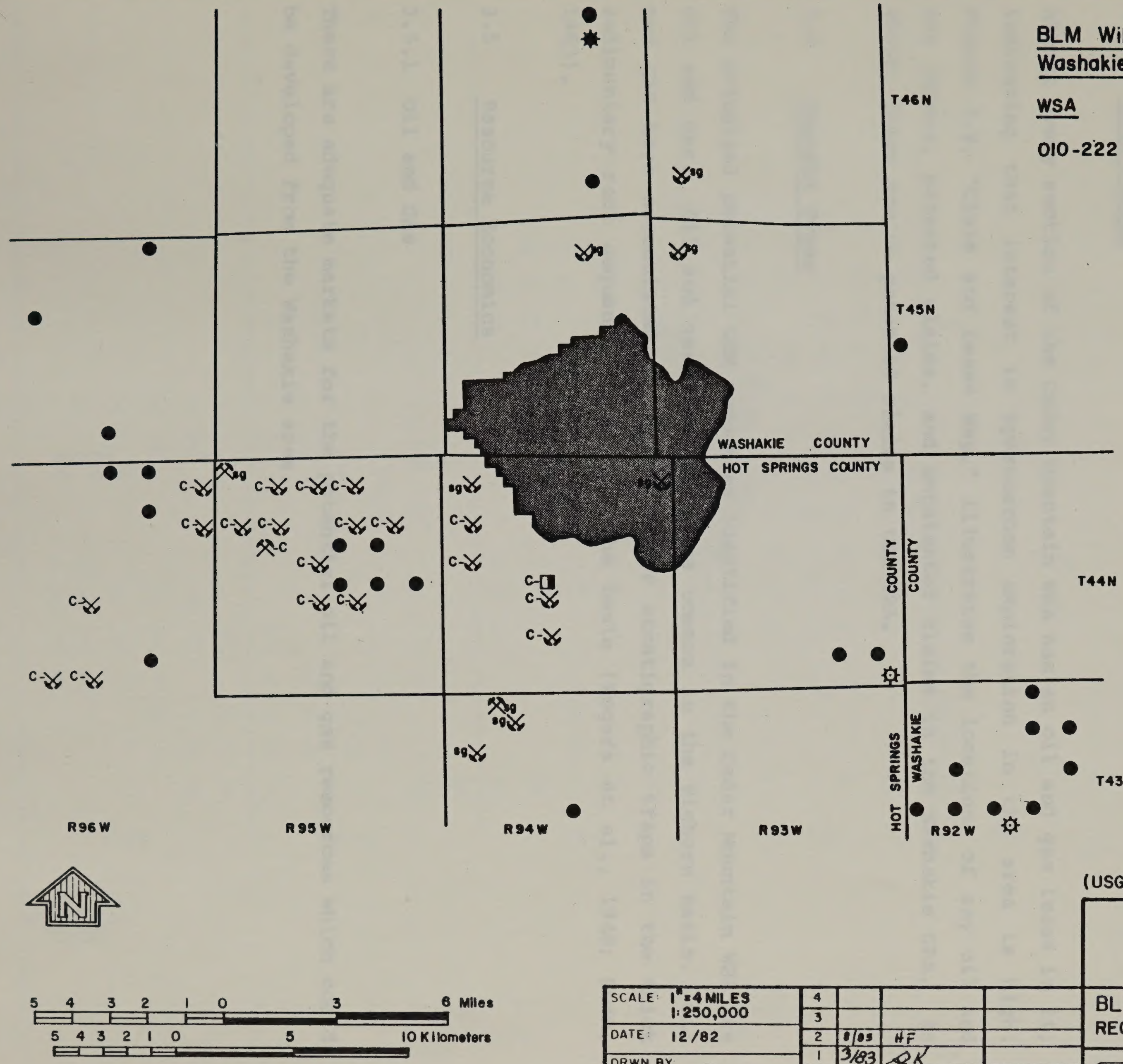
3.1 General

There are no known energy or mineral resources in the Cedar Mountain WSA. The only potential resource of any significance in the area is oil and gas. Some small coal deposits in the area could possibly be developed.

Figure 3.1, "Mineral Occurrence Map," illustrates the presence of any known past and present mine locations, or occurrences of mineral deposits and GEM resources within the GRA. Information for this figure came from the USGS' Computerized Resource Information Bank (CRIB); the USBM's Minerals Availability Information System (MILS); and Petroleum Information Corporation (PI) Dry Hole Maps.

3.2 Potential Resources

Several holes have been drilled in or adjacent to the Washakie GRA in the search for oil and gas. The Gebo Oil Field is located about six miles west of the area (Figure 3.1). Cretaceous through Paleozoic age rocks underlie the area; these rocks have been sources of petroleum products from structural or stratigraphic traps in other areas of the basin (PI, 1982). Specific producing zones could be identified by examining well logs. Coal occurs



BLM Wilderness Study Areas Included in the Washakie GRA

WSA	NAME	ACREAGE
010-222	Cedar Mountain	21,570

●	Oil Well
☼	Gas Well
✸	Oil & Gas Well
⚒	Mine
⚒	Inactive Mine
■	Ore Body
◧	Deposit
▨	Approximate Boundary of Wilderness Study Area

COMMODITY

c	Coal
sg	Sand and Gravel

(USGS, 1982; USBM, 1982; PI, 1982)

Washakie GRA, Wyoming

MINERAL OCCURRENCE MAP

BLM GEM RESOURCES ASSESSMENT
REGION 6 WYOMING and MONTANA

TETRA TECH INC.
PASADENA, CALIFORNIA

FIGURE 3.1

SCALE:	1"=4 MILES 1:250,000
DATE:	12/82
DRWN BY	SK
APRVD	WL

	DATE	DRWN BY	APRVD
4			
3			
2	8/85	HF	
1	3/83	QK	

REVISIONS

in the Mesaverde, Meeteetse, Lance and Fort Union Formations in the Bighorn Basin. The very southern portion of the study area would be within the northwest section of the Southeastern Coal Field as defined by the USGS (1964). The USGS states that coal in the Southeastern Coal Field occurs in the Mesaverde and Fort Union Formations; the USGS further states that the coal beds present are fairly continuous but are too thin to be mined. The coal beds are subbituminous in grade and of relatively poor quality.

3.3 Land Status

Almost every section of the Cedar Mountain WSA has an oil and gas lease in it, indicating that interest in hydrocarbon exploration in the area is high. Figure 3.2, "Claim and Lease Map," illustrates the locations of any oil and gas leases, patented claims, and unpatented claims in the Washakie GRA. As shown, there are no patented claims in the GRA.

3.4 Deposit Types

The principal potential GEM resources identified in the Cedar Mountain WSA are oil and gas. Oil and gas reservoirs are common in the Bighorn Basin. Oil and gas have accumulated in structural or stratigraphic traps in the thick sedimentary rock sequence that fills the basin (Rogers et al., 1948; Horn, 1963).

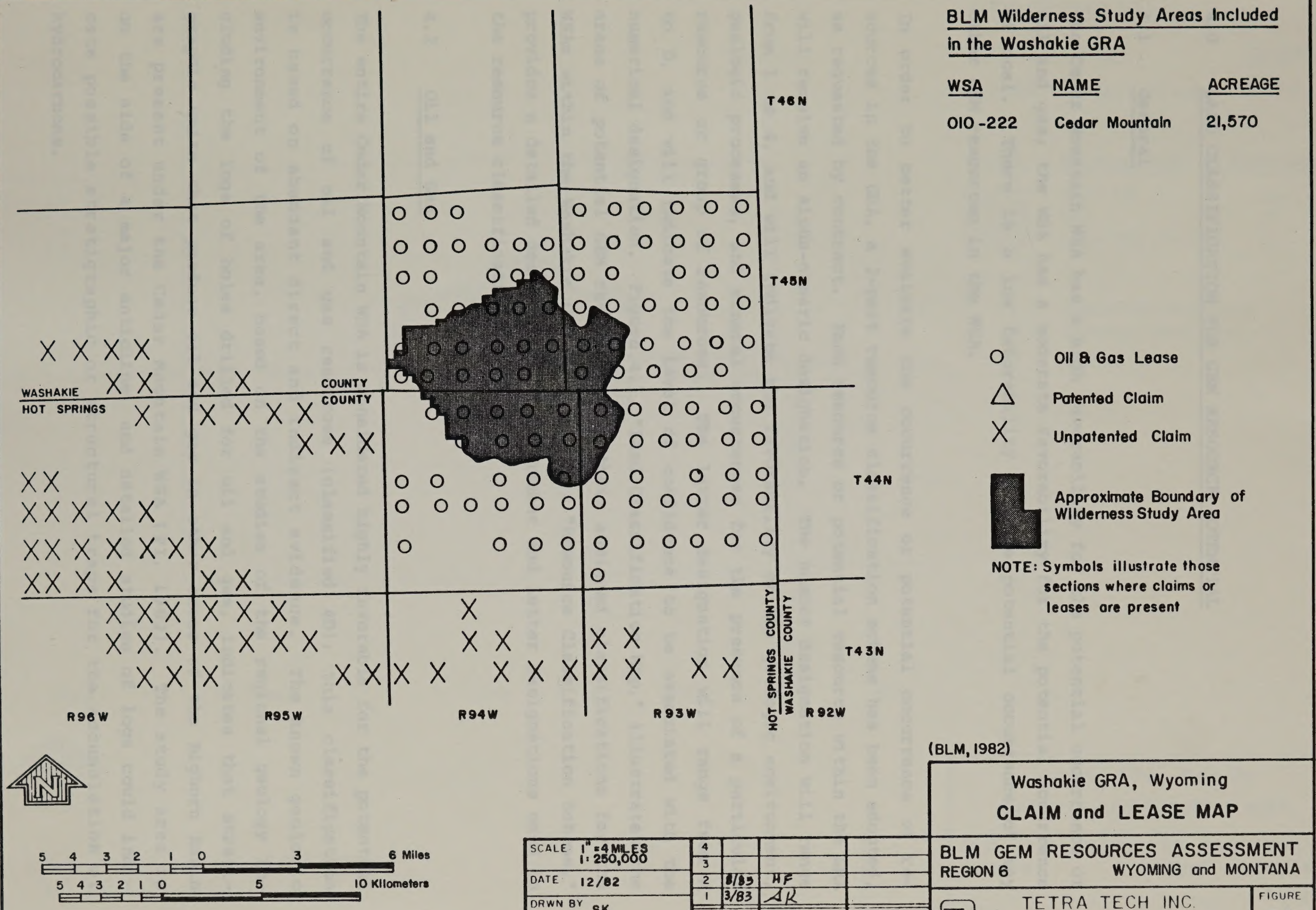
3.5 Resource Economics

3.5.1 Oil and Gas

There are adequate markets for the potential oil and gas resources which could be developed from the Washakie area.

BLM Wilderness Study Areas Included in the Washakie GRA

WSA	NAME	ACREAGE
010-222	Cedar Mountain	21,570



NOTE: Symbols illustrate those sections where claims or leases are present

(BLM, 1982)

Washakie GRA, Wyoming

CLAIM and LEASE MAP

BLM GEM RESOURCES ASSESSMENT
REGION 6 WYOMING and MONTANA

TETRA TECH INC.
PASADENA, CALIFORNIA

FIGURE 3.2

SCALE	1" = 4 MILES 1: 250,000
DATE	12/82
DRWN BY	SK
APRVD	WL

	DATE	DRWN BY	APRVD
4			
3			
2	8/83	HF	
1	3/83	AR	

REVISIONS

4.0 LAND CLASSIFICATION FOR GEM RESOURCE POTENTIAL

4.1 General

The Cedar Mountain WSA has a high favorability for the potential occurrence of oil and gas; the WSA has a moderate favorability for the potential occurrence of coal. There is a low favorability for the potential occurrence of any other GEM resources in the WSA.

In order to better evaluate the occurrence or potential occurrence of resources in the GRA, a 2-part resource classification scheme has been adopted, as requested by contract. Each resource or potential resource within the GRA will receive an alpha-numeric designation. The number designation will range from 1 to 4, and will indicate the favorability of the geologic environment, geologic processes, and mineral occurrences for the presence of a particular resource or group of resources. The letter designation will range from A to D, and will indicate the level of confidence to be associated with the numerical designation. Figure 4.1, "Land Classification Map," illustrates the areas of potential GEM resources with their assigned classifications for the WSAs within the Washakie GRA. Figure 4.2, "Resource Classification Scheme," provides a detailed description of the number and letter designations used in the resource classification scheme.

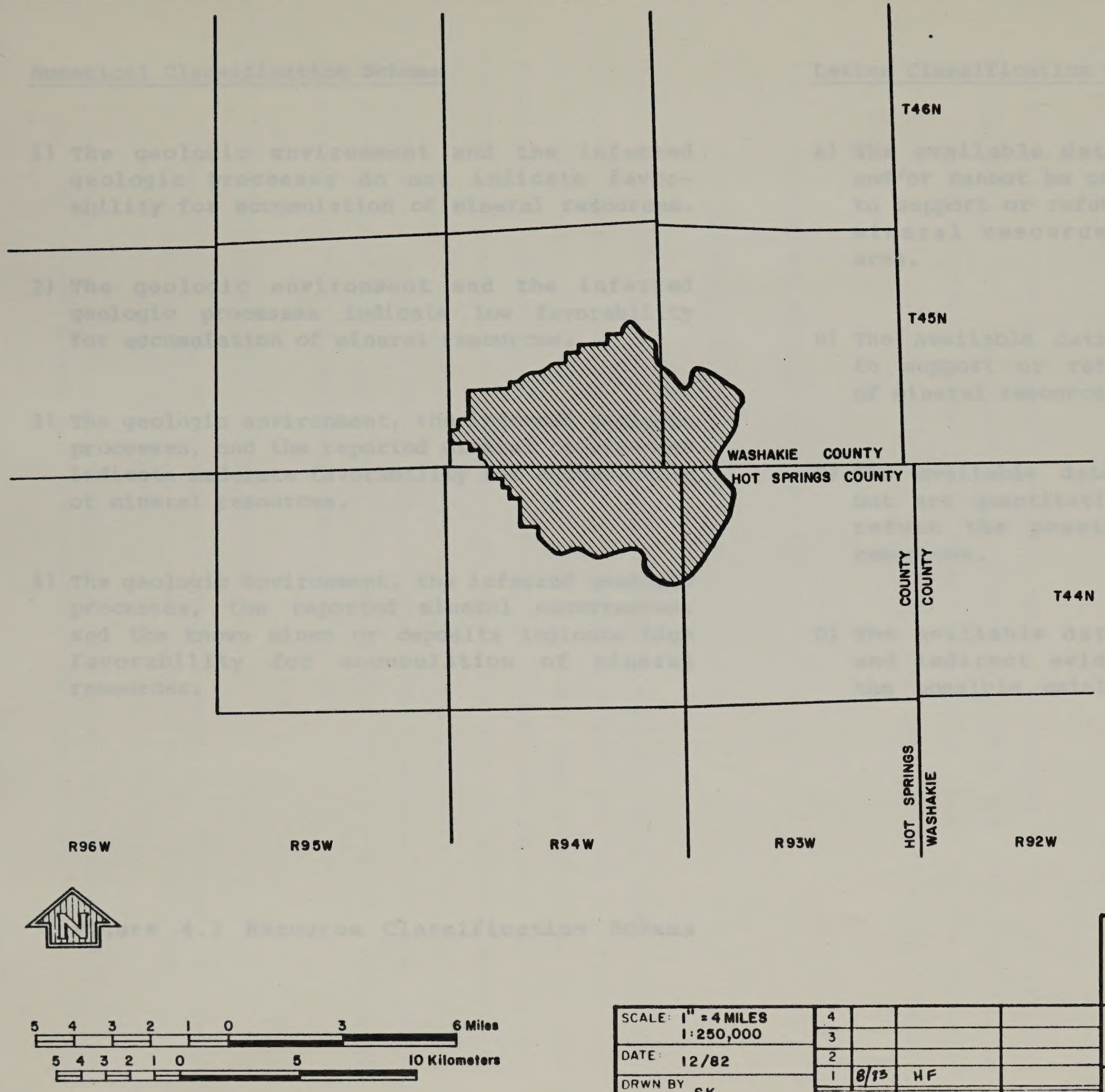
4.2 Oil and Gas

The entire Cedar Mountain WSA is considered highly favorable for the potential occurrence of oil and gas resources (classified 4D); this classification is based on abundant direct and indirect evidence. The known geologic environment of the area, based on the studies of the regional geology including the logs of holes drilled for oil and gas, indicates that stratigraphic units that produce oil and gas in other areas of the Bighorn Basin are present under the Cedar Mountain WSA (PI, 1982). The study area is on the side of a major anticline, and detailed studies of logs could indicate possible stratigraphic or structural traps for the accumulation of hydrocarbons.

BLM Wilderness Study Areas Included in the Washakie GRA

WSA	NAME	ACREAGE
010-222	Cedar Mountain	21,570

SYMBOL	GEM RESOURCE	CLASSIFICATION
▨	Oil & Gas Coal Other GEM Resources	4D 3C 2C
☐	Approximate Boundary of Wilderness Study Area	



Washakie GRA, Wyoming

LAND CLASSIFICATION MAP

BLM GEM RESOURCES ASSESSMENT
REGION 6 WYOMING and MONTANA

TETRA TECH INC.
PASADENA, CALIFORNIA

FIGURE 4.1

SCALE: 1" = 4 MILES 1:250,000	4		
	3		
DATE: 12/82	2		
DRWN BY SK	1	8/83	HF
APRVD WL	DATE	DRWN BY	APRVD
	REVISIONS		

Numerical Classification Scheme

1) The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.

2) The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.

3) The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.

4) The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.

Letter Classification Scheme (Level of Confidence)

A) The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.

B) The available data provide indirect evidence to support or refute the possible existence of mineral resources.

C) The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.

D) The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

Figure 4.2 Resource Classification Scheme

4.3. Coal

The Cedar Mountain WSA is considered to have a moderate favorability for the potential occurrence of coal resources (classified 3C); this classification is based upon direct but quantitatively minimal evidence. The available evidence suggests that coal of significant value may possibly occur beneath the WSA (USGS, 1964).

4.4 Other GEM Resources

Quantitatively minimal direct evidence exists to support a low favorability classification for the potential occurrence of other GEM resources in the WSA (classified 2C). This classification is also based on the geologic environment and inferred geologic processes that have been identified within the WSA.

5.0 RECOMMENDATIONS FOR FURTHER WORK

5.1 Work Recommended to Complete Data Base

A number of investigations could be implemented to generate additional data to supplement the conclusions of this Phase I report for the Washakie GRA. The logs of holes drilled for oil and gas within and adjacent to the area should be acquired, plotted accurately on a map, and studied in detail. Geologic sections should be constructed across the area to identify changes in stratigraphy and the possible existence of suitable structures for hydrocarbon accumulation. Based on these data, an experienced petroleum geologist should be able to make predictions as to the possibility of discovering oil and gas by drilling within the Washakie area.

6.0 REFERENCES AND SELECTED BIBLIOGRAPHY

1. Atomic Energy Commission, Division of Raw Materials. 1950-58. Preliminary Reconnaissance Reports on Reported Occurrences of Uranium Deposits, Wyoming, Hot Springs County. U.S. Geological Survey.
2. Barlow & Haun, Inc. 1977. Structure Contour Map of Southeast 1/4 Bighorn Basin Wyoming. The Petroleum Ownership Company.

3. Barrell, S. Washakie Resource Area Mineral Maps (10). U.S. Bureau of Land Management, Washakie Resource Area.

4. Bown, T.M. 1977. Geology and Mammalian Paleontology of the Sand Creek Facies, Lower Willwood Formation (Early Eocene), Washakie County, Wyoming. Dissertation Abstracts International.

5. Damp, J. and Brown, L. 1982. National Uranium Resource Evaluation, Arminto Quadrangle, Wyoming. U.S. Department of Energy, PGJ/F-018 (82).

6. Herrod, W.H. 1980. Relationship of Cottonwood Creek Field, Washakie County, Wyoming to Carbonate Facies of Permian Goose Egg Formation Eastern Bighorn Basin. Unpublished Ph.D. Thesis for Colorado School of Mines.

7. Horn, G.H. 1963. Geology of the East Thermopolis Area, Hot Springs and Washakie Counties, Wyoming. U.S. Geological Survey, Oil and Gas Investigations Map OM-213.

8. Lillegraven, R.J. 1982. University of Wyoming. Personal Communication.

9. Love, J.D; Christiansen, A.C.; Brown, T.M.; and Earle, J.L. 1979. Preliminary Geologic Map of the Thermopolis 1° x 2° Quadrangle, Wyoming. U.S. Geological Survey Open File Report 79-962.

10. Mackenzie, M.G. Stratigraphy and Petrology of the Mesaverde Group, Southern Part of the Bighorn Basin, Wyoming. Tulane University.

11. Mirsky, A. 1962. Stratigraphic Sections of Upper Jurassic and Lower Cretaceous Rocks in the Southern Bighorn Mountains, Wyoming. Geological Survey of Wyoming, Report on Investigations No. 8.

12. Osterwald, D.B.; Osterwald, F.W. et al. 1959; revised by Wilson, W.H. 1966. Mineral Resources of Wyoming. Geological Survey of Wyoming, Bulletin 50.

13. Petroleum Information Corporation. 1982. The Petroleum Ownership Map Company, Southeast 1/4 Bighorn Basin, Wyoming.

14. Rogers, C.P. et al. 1948. Geology of the Worland-Hyattville Area, Big Horn and Washakie Counties, Wyoming. U.S. Geological Survey Oil and Gas Investigation, Preliminary, Map 84.

15. Ugolini, F. 1982. National Park Service. Personal Communication. List of National Registry of National Landmarks, (List of Geologic Features Designated as National Landmarks); and List of Recommended Geologic Features in Natural History Theme Studies for Montana (updated December 1981), and Wyoming (updated March 1981).

16. U.S. Bureau of Land Management. 1982. Master Title Plats. Plats for the study areas were supplied to Tetra Tech by the U.S. Bureau of Land Management in August, 1982.

17. U.S. Bureau of Mines. 1982. Minerals Availability System (MILS) Deposit Listings. Listings for the study areas were supplied to Tetra Tech by the U.S. Bureau of Mines in August, 1982.

18. U.S. Department of the Interior, Minerals Management Service. 1979. Bentonite in the Worland District. U.S. Bureau of Land Management Unpublished Report.

19. U.S. Geological Survey. n.d. Thermopolis 1° x 2° Topographic Quadrangle, scale 1:250,000, contour interval 200 feet, Thermopolis, Wyoming, NK 12-3, Series V502, Edition 1-A15.

20. U.S. Geological Survey. 1937. Geologic Map of Hot Springs County, Wyoming. Geological Survey of Wyoming.

21. U.S. Geological Survey. 1955; revised 1974. Arminto 1° x 2° Topographic Quadrangle, scale 1:250,000, contour interval 200 feet, Arminto, Wyoming, NK 13-1, Series V502.

22. U.S. Geological Survey. 1964. Mineral Resource Report, Bighorn Basin, Wyoming and Montana (unpublished).

23. U.S. Geological Survey. 1982. Computerized Resource Information Bank (CRIB) Mineral Resources Files. Files for the study area were supplied to Tetra Tech by the U.S. Geological Survey in August, 1982.

24. Woodruff, E.G. 1907. Contributions to Economic Geology, 1907--Part 2. Coal Fields of the Southwest Side of the Bighorn Basin, Wyoming. U.S. Geological Survey, Bulletin 341.

25. Wyoming Geological Survey. 1937. Geological Map of Hot Springs County, Wyoming.

USDI – BLM

DATE LOANED	BORROWER

QE 182 .W91 G46 c.3
Geology, energy, and m
(GEM) resource assessm

BORROWER'S CARD
Form 1279-3
(June 1984)